Taxonomy of bacteria

Taxonomy: is the branch of biological science dealing with naming, and grouping organisms based on the degree of similarity and arranging them in an order based on their evolutionary relationship. (Greek. '**Taxis**'— arrangement; '**nomos**'— law).

Aims of Taxonomy

• Classification of organisms

• Show relationships among organisms

• Way to provide universal identification of an organism.

Bacterial taxonomy is a subfield of taxonomy devoted to the classification of bacteria specimens into taxonomic ranks.

Bacterial taxonomy consists of three separate, but highly interrelated areas:-

1-Classification: is the arrangement of organisms into groups or taxa (singular: taxon) on the basis of similarities or evolutionary relatedness.

*Taxon (plural - taxa): is a group or category of related organisms

2-Nomenclature (naming): is the assignment of names to the taxonomic groups according to international rules (rules are published in the International Code of Nomenclature of Bacteria). The rules are maintained by ICSP (International Committee on Systematics of Prokaryotes).

3-Identification: is the practical side of taxonomy, which is the process of determining that a particular isolate belongs to a recognized taxon.

* It is to mention here that the term **Bacterial systematics** often is used for **bacterial taxonomy.**

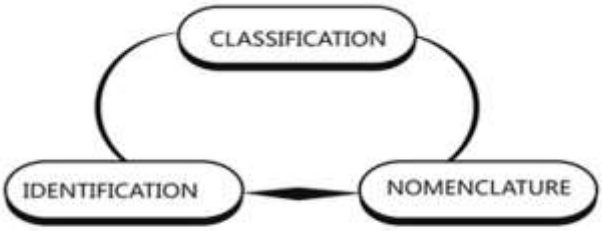
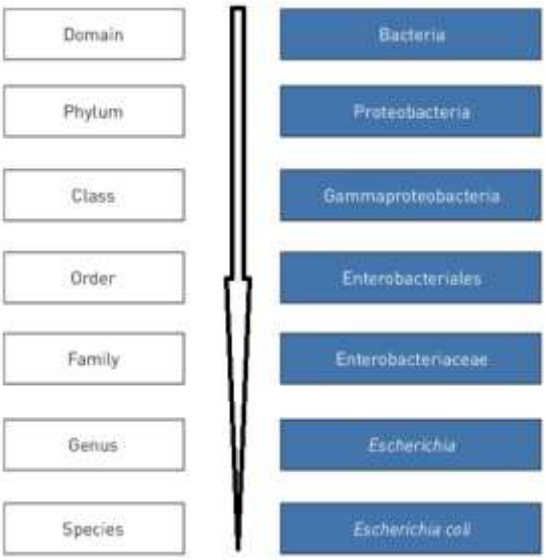


Figure 8.1 Three facets of taxonomy

Ranks or Levels of Bacterial Taxonomy:

* * In bacterial taxonomy, the most commonly used ranks or levels in their ascending order are **species, genera, families, orders, classes, phyla, and domains.**

***Species** is the basic taxonomic group in bacterial taxonomy. Groups of species are then collected into **genera** (sing, genus). Groups of genera are collected into **families** (sing, family), families into **orders**, orders into **classes**, classes into **phyla** (sing, phylum), and phyla into **domain** (the highest rank or level). Groups of bacteria at each rank or level have names with endings or suffixes characteristic to that rank or level.



Taxonomic classification of *Escherichia coli*.

*Binomial nomenclature

Binomial nomenclature is the system that is still used today to name all living things (viruses are exceptions).

Binomial nomenclature employs the names of the two lower level **taxa (sing . taxon)), genus and species**, to name a species:-

• Genus comes before species (e.g., *Escherichia coli*)

• Genus name is always capitalized (e.g., Escherichia)

• Species name is in small letter (e.g., coli)

• Both names are always either italicized or underlined (e.g., *Escherichia coli* or Escherichia coli)

•The genus name may be used alone, but not the species name (i.e., saying or writing "Escherichia," alone is legitimate while saying or writing "coli" is not).

Approaches to Taxonomy of Bacteria

To classify bacteria, these main approaches are used:

1. Phenotypic approach: Based on morphology, biochemical reactions, and antibiotic susceptibility.

2. Genotypic approach: Involves gene analysis like 16S rRNA sequencing and whole genome sequencing.

3. Phylogenetic approach: Uses evolutionary relationships through phylogenetic trees based on conserved genes.

4. Chemotaxonomic approach: Analyses cell components like cell wall structure and fatty acid profiles.

5. Ecological approach: Considers the bacteria's habitat and environmental characteristics.

Typically, a combined approach is used for accurate classification.

***Phenotypic Taxonomy (Numerical Taxonomy, Classical Taxonomy, Computer Taxonomy):

In phenotypic taxonomy many (50 to 200) biochemical, morphological, and cultural characteristics, as well as susceptibilities to antibiotics and inorganic compounds, are used to determine the degree of similarity between organisms. In numerical studies, investigators often calculate the coefficient of similarity or percentage of similarity between strains. **A dendrogram** (from the Greek **dendron "tree" and gramma "drawing"**) or **a similarity** matrix is constructed that joins individual strains into groups and places one group with other groups based on their percentage of similarity.

Phenotypic characteristics useful in classification and identification, including:

1-Morphologic Characteristics

The simple tests for bacteria can indicate the Gram reaction of the organism; whether it is acid-fast; its motility; the arrangement of its flagella; the presence of spores, capsules, and inclusion bodies; and, of course, its shape. This information often can allow identification of an organism to the genus level, or can minimize the possibility that it belongs to one or another group.

2-Growth Characteristics

A primary distinguishing characteristic is whether an organism grows aerobically, anaerobically, facultatively (i.e., in either the presence or absence of oxygen), or microaerobically (i.e., in the presence of a less than atmospheric partial pressure of oxygen). The proper atmospheric conditions are essential for isolating and identifying bacteria. Other

important growth assessments include the incubation temperature, pH, nutrients required, and resistance to antibiotics.

3-Antigens and Phage Susceptibility

Cell wall (O), flagellar (H), and capsular (K) antigens are used to aid in classifying certain organisms at the species level, to serotype strains of medically important species for epidemiologic purposes, or to identify serotypes of public health importance.

Phage typing (determining the susceptibility pattern of an isolate to a set of specific bacteriophages) and susceptibility to bacteriocins has been used primarily as epidemiologic strain marker.

4-Biochemical Characteristics

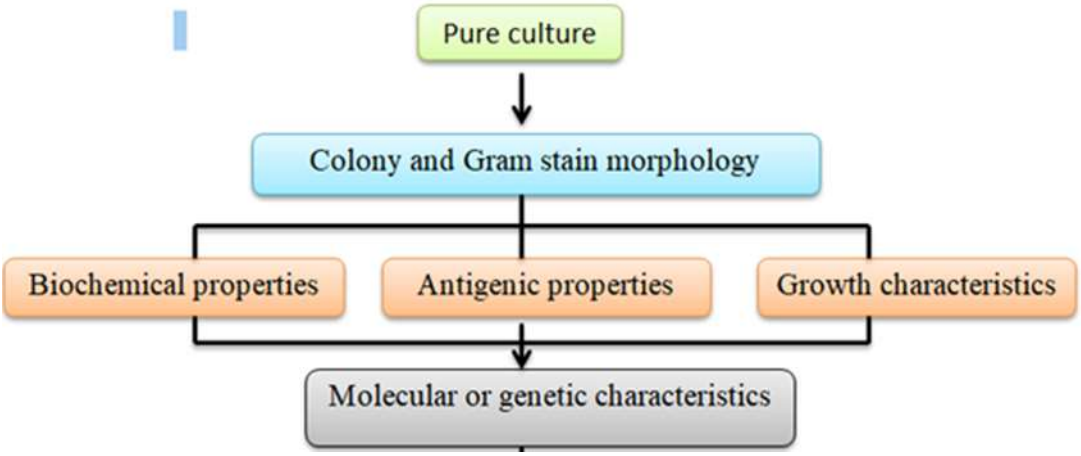
Most bacteria are identified and classified largely on the basis of their reactions in a series of biochemical tests. Some tests are used routinely for many groups of bacteria (oxidase, nitrate reduction, amino acid degrading enzymes, fermentation or utilization of carbohydrates); others are restricted to a single family, genus, or species (coagulase test for staphylococci).

***Bergey's Manual**

Methods for distinguishing and identifying bacteria are assembled into Bergey's Manual of Determinative Bacteriology

— Bergey's Manual of Systematic Bacteriology:

Describes physical & chemical Characteristics and system of identification of medically important members of selected sections of bacteria



Bacterial identification

***Phylogenetic Taxonomy (Molecular taxonomy):**

*An evolutionary arrangement of species.

*** Genetic Homology:** is a similarity between two organisms that exists. The similarity of the DNA (or RNA) of organisms may be determined by a number of molecular methods **including:**

a- Genomic DNA GC ratios (G + C content) or Base composition.

b- Nucleic acid hybridization (Genomic hybridization).

c- Nucleic acid sequencing.

d- Ribotyping

e- Comparison of proteins (Protein profiles and amino acid sequences)

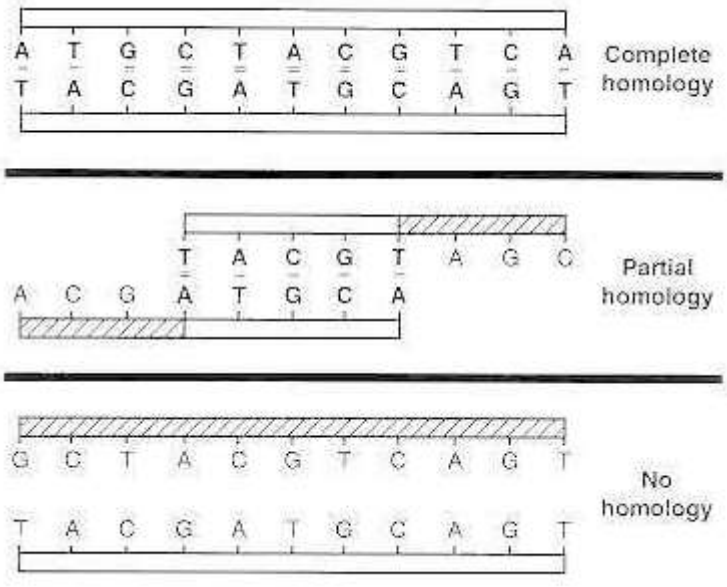


Diagram of DNA reassociation

(Top) perfectly reassociated DNA base sequence in which all nucleosides are paired by hydrogen bonds. (Middle) perfectly paired DNA base sequence in the center with unpaired, single-strand ends on each strand. (Bottom) none of the bases in the sequence (left to right) GCTACGTCAGT on the top strand are complementary to the sequence TACGATGCAGT in the bottom strand.